Core Content

Cluster Title: Experiment with transformations in theplane.
Standard G.CO.1: Know precise definitions of angle, circle, perpendicular line,parallel line, and line segment, based on the undefined notions of point,line, distance along a line, and distance around a circular arc.
Concepts and Skills to Master
• Define angle, circle, perpendicular line,parallel line, and line segment. • Use precise definitions to identify and model an angle, circle, perpendicular line, parallel line, and line segment. • Demonstrate mathematical notation for each term.

Supports for Teachers

Critical Background Knowledge	
• Understanding the undefined terms point, line, and plane. • Understand distance is a non-negative quantity.	
Academic Vocabulary	
angle, circle, perpendicular line, parallel line, line segment, distance, arc	
Suggested Instructional Strategies	**Resources**
• Have students write their own understanding of a given term. • Give students formal and informal definitions of each term and compare them. • Develop precise definitions through use of examples and non-examples. • Discuss the importance of having precise definitions.	
Sample Formative Assessment Tasks	
Skill-based Task State the definition of a circle.	**Problem Task** Identify real-life examples of each term in the student's environment, using definitions.

Core Content

Cluster Title: Experiment with transformations in the plane.
Standard G.CO.2: Represent transformations in the plane using (e.g., transparencies and geometry software); describe transformations as functions that take points in the plane as inputs and give other points as outputs. Compare transformations that preserve distance and angle to those that do not (e.g., translation versus horizontal stretch).
Concepts and Skills to Master
• Represent reflections, rotations and translations using a variety of media. • Compare and contrast rigid and non-rigid transformations. • Understand transformations as functions that take points in the plane as inputs and give other points as outputs.

Supports for Teachers

Critical Background Knowledge	
• Identify different types of transformations.	
Academic Vocabulary	
Plane, transformation, reflection, rotation, translation, preserve, function in terms of input and output	
Suggested Instructional Strategies	**Resources**
• Understand that a function has one output for every input whether the input is a number or a point in the plane. • Use M.C. Escher pictures to compare and contrast rigid and non-rigid transformations.	
Sample Formative Assessment Tasks	
Skill-based Task Which of the following preserves distance and which does not? $(x, y) \rightarrow (x+1, y+2)$ $(x, y) \rightarrow (x^2, y+1)$	**Problem Task** If a transformation preserves distances, what other information would you need to know to determine an output for the point (1,0)?

Core Content

Cluster Title: Experiment with transformations in theplane.
Standard G.CO.3: Given a rectangle, parallelogram, trapezoid, or regular polygon, describe the rotations and reflections that carry it onto itself.
Concepts and Skills to Master
• Describe and identify lines and points of symmetry. • Describe rotations and reflections which take a rectangle, parallelogram, trapezoid, or regular polygon onto itself.

Supports for Teachers

Critical Background Knowledge	
• Understand lines of symmetry. • Understand properties of rectangle, parallelogram, trapezoid, and regular polygons such as angle measures and side lengths.	
Academic Vocabulary	
Rectangle, parallelogram, trapezoid, regular polygon, rotation, reflection, symmetry	
Suggested Instructional Strategies	**Resources**
• Provide sets of polygons for students to manipulate. • Use mirrors or a reflective device to help students see lines of symmetry.	http://illuminations.nctm.org Frieze http://illuminations.nctm.org Symmetries II

Sample Formative Assessment Tasks	
Skill-based Task Draw the lines of reflection symmetry that would carry the polygon onto itself. 	**Problem Task** Given any number between 0 and 180, can you find a polygon that has that rotational symmetry? Explain.

Core Content

Cluster Title: Experiment with transformations in theplane.
Standard G.CO.4: Develop definitions of rotations, reflections, and translations in terms of angles, circles, perpendicular lines, parallel lines, and line segments.
Concepts and Skills to Master
• Through observations and conjectures develop definitions of rotations, reflections, and translations. • Define rotations, reflections, and translations using angles, circles, perpendicular lines, parallel lines, and line segments.

Supports for Teachers

Critical Background Knowledge	
• Use inductive reasoning to make conjectures. • Know definitions and properties of angles, circles, perpendicular lines, parallel lines, and linesegments.	
Academic Vocabulary	
angle, circle, perpendicular lines, parallel lines, line segment, rotation, reflection, translation, conjecture, inductive reasoning	
Suggested Instructional Strategies	**Resources**
• Draw rotations, reflections, and translations. • Use geometry software to model rotations, reflections, and translations.	http://illuminations.nctm.org Symmetries II

Sample Formative Assessment Tasks	
Skill-based Task Perform a rotation, reflection, and translation with a given polygon and give a written explanation of how each step meets the definitions of each transformation using correct mathematical terms.	**Problem Task** Given a polygon and its transformation, identify the angle of rotation or the distance of translation.

Core Content

Cluster Title: Experiment with transformations in theplane.
Standard G.CO.5: Given a geometric figure and a rotation, reflection, or translation, draw the transformed figure using, e.g., graph paper, tracing paper, or geometry software. Specify a sequence of transformations that will carry a given figure onto another.
Concepts and Skills to Master
• Perform rotations, reflections and translations using a variety of methods. • Identify the sequence of transformations that will carry a given figure to another. • Understand that the composition of transformations is not commutative.

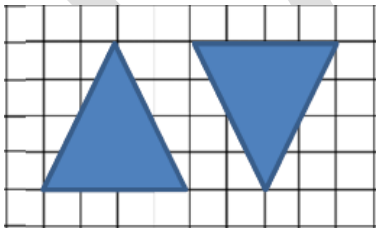
Supports for Teachers

Critical Background Knowledge	
• Understand the significance of the order in mathematics.	
Academic Vocabulary	
Rotation, reflection, translation	
Suggested Instructional Strategies	**Resources**
• Have students use a variety of tools to explore and perform simple, multi-step, and composite rotations, reflections, and translations. • Given a transformation, work backwards to discover the sequence that led to that transformation.	
Sample Formative Assessment Tasks	
Skill-based Task Given ∆ ABC, reflect it about intersecting lines *l*&*m*. Identify the angle of rotation.	**Problem Task** Prove that every rotation is a composition of two reflections.

Core Content

Cluster Title: Understand congruence in terms of rigid motions.
Standard G.CO.6: Use geometric descriptions of rigid motions to transform figuresand to predict the effect of a given rigid motion on a given figure; giventwo figures, use the definition of congruence in terms of rigid motionsto decide if they are congruent.
Concepts and Skills to Master
• Transform figures using geometric descriptions of rigid motions. • Predict the effect of rotating, reflecting or translating a given figure. • Justify the congruence of two figures using properties of rigid motions.

Supports for Teachers

Critical Background Knowledge	
• Understand and use reflections, translations, and rotations.	
Academic Vocabulary	
Rigid motion, congruent, rotate, translate, reflect	
Suggested Instructional Strategies	**Resources**
• Use graph paper, tracing paper, physical models and geometry software to verify predictions regarding rigid motion and congruence. • Use frieze patterns and Escher art to explore congruency in transformations.	Polystrips Math Open Reference: http://www.mathopenref.com/congruenttriangles.html http://illuminations.nctm.org Frieze Patterns
Sample Formative Assessment Tasks	
Skill-based Task Describe a series of transformations that would generate the second triangle from the first. What is the relationship between the two triangles? 	**Problem Task** Create frieze patterns and tessellations using transformations that preserve congruence.

Core Content

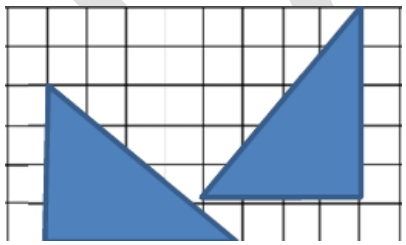
Cluster Title: Understand congruence in terms ofrigid motions.
Standard G.CO.7: Use the definition of congruence in terms of rigid motions to show that two triangles are congruent if and only if corresponding pairs of sides and corresponding pairs of angles are congruent.
Concepts and Skills to Master
• Identify corresponding parts of two triangles. • Show that two triangles are congruent if and only if corresponding pairsof sides and corresponding pairs of angles are congruent (CPCTC).

Supports for Teachers

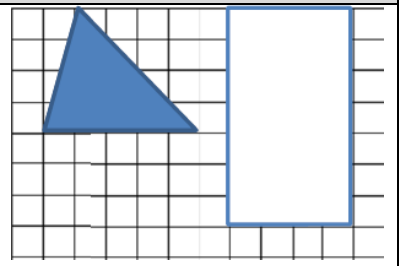
Critical Background Knowledge	
• Define congruence in terms of rigid motions. • Understand that rigid motion is any combination of reflection, translation, and rotation preserving angle measure and side length.	
Academic Vocabulary	
If and only if (iff), corresponding, rigid motion, congruent	
Suggested Instructional Strategies	**Resources**
• Match pairs of cardboard congruent triangles and justify congruence. • Measure angles and side lengths of triangles resulting from rigid transformations using a variety of technology and paper based methods (e.g., patty paper).	Math Open Reference: http://www.mathopenref.com/congruenttriangles.html

Sample Formative Assessment Tasks

Skill-based Task
Identify the corresponding parts of the two congruent triangles.



Problem Task
How many ways can you construct a triangle congruent to the given triangle inside the rectangle? Demonstrate each.

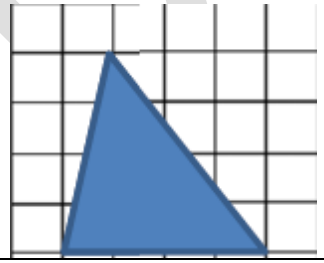


Core Content

Cluster Title: Understand congruence in terms of rigid motions.
Standard G.CO.8: Explain how the criteria for triangle congruence (ASA, SAS, andSSS) follow from the definition of congruence in terms of rigid motions.
Concepts and Skills to Master
• Identify the minimum conditions necessary for triangle congruence (ASA, SAS, and SSS). • Understand, explain, and demonstrate why ASA, SAS, or SSS are sufficient to show congruence. • Understand, explain, and demonstrate why SSA and AAA are not sufficient to show congruence.

Supports for Teachers

Critical Background Knowledge	
• Definition of congruence in terms of rigid motions. • Definition of corresponding pairs of sides or angles.	
Academic Vocabulary	
ASA, SAS, SSS, AAA, SSA, included angle, included side, corresponding parts	
Suggested Instructional Strategies	**Resources**
• Explore the minimum conditions necessary to show triangles are congruent using technology, reflective devices, patty paper, spaghetti, or grid paper. • Establish triangle congruence criteria using properties of rigid motion.	*Making it Happen* (NCTM)

Sample Formative Assessment Tasks	
Skill-based Task Use rigid motions to transform three segments or angles of the triangle and determine whether or not the resulting triangle is congruent. Explain your conclusion. 	**Problem Task** Demonstrate visually why some conditions like SSA or AAA are not sufficient to show congruence.

Core Content

Cluster Title: Make geometric constructions.
Standard G.CO.12: Make formal geometric constructions with a variety of tools and methods (compass and straightedge, string, reflective devices, paper folding, dynamic geometric software, etc.): copying a segment; copying an angle; bisecting a segment; bisecting an angle; constructing perpendicular lines, including the perpendicular bisector of a line segment; and constructing a line parallel to a given line through a point not on the line.
Concepts and Skills to Master
• Perform the following constructions using a variety of tools and methods: copying a segment; copying an angle; bisecting a segment; bisecting an angle; constructing perpendicular lines, including the perpendicular bisector of a line segment; and constructing a line parallel to a given line through a point not on the line. • Explain why these constructions result in the desired objects.

Supports for Teachers

Critical Background Knowledge	
• Define the following terms: circle, bisector, perpendicular and parallel.	
Academic Vocabulary	
Segment, angle, bisect, perpendicular, parallel, circle, construction	
Suggested Instructional Strategies	**Resources**
• Have students explore how to make a variety of constructions using different tools. Ask students to justify how they know their method results in the desired construction. • Discuss the underlying principles that different tools rely on to produce desired constructions (e.g., compass: circles, mira: reflections).	http://www.mathopenref.com/tocs/constructionstoc.html http://whistleralley.com/construction/reference.htm
Sample Formative Assessment Tasks	
Skill-based Task Construct a perpendicular bisector of the given line segment.	**Problem Task** Given two quadrilaterals that are reflections of each other, find the line of that reflection.

Core Content

Cluster Title: Make geometric constructions.
Standard G.CO.13: Construct an equilateral triangle, a square, and a regularhexagon inscribed in a circle.
Concepts and Skills to Master
• Construct an equilateral triangle, a square, and a regular hexagon. • Construct an equilateral triangle, a square, and a regular hexagon each inscribed in a circle.

Supports for Teachers

Critical Background Knowledge	
• Understand the properties of regular polygons. • Construct congruent segments and perpendicular lines.	
Academic Vocabulary	
Equilateral triangle, square, regular hexagon, inscribed, construction	
Suggested Instructional Strategies	**Resources**
• Allow students to explore possible methods for constructing equilateral triangles, squares, and hexagons, and methods for constructing each inscribed in a circle.	http://www.mathopenref.com/tocs/constructionstoc.html http://whistleralley.com/construction/reference.htm
Sample Formative Assessment Tasks	
Skill-based Task Construct an equilateral triangle inscribed in a circle using a compass and straight-edge.	**Problem Task** Find two ways to construct a hexagon inscribed in circle as shown.